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# Internal Curing Efficiency of Pre-Wetted Lightweight Fine Aggregates on Strength Parameters of Concrete

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***Abstract:** Internal cured concrete (ICC) using pre-wetted lightweight aggregates is to replace conventional type of curing. Normally curing for conventional type is done by external to internal, which requires a large membrane and a large amount of water is required to do this type of procedure and the water which we use for curing may get runoff or get evaporated. But in ICC type of curing it cure inside to outside, the pre-wetted lightweight aggregates provides sufficient moisture to hydrate cement inside the concrete. The pre-wetted light weight aggregates, which stores water inside and acts as a reservoir. It release water when hydration process is done. Lightweight aggregates such as expanded clay or shale, vermiculite, pumice, slate, perlite having high water absorbing capacity are generally used for internal cured concrete. In this study, vermiculite and expanded clay had been used as replacements of fine aggregate, 2.5%, 5%, 7.5%, 10% and 12.5% are replaced for vermiculite and 5%, 10%, 15%, 20% and 25% for expanded clay.*

***Keywords:***

## I. INTRODUCTION

Concrete is a composite material composed of hydrated cement (binder), sand (fine aggregate), gravels or crushed stones (coarse aggregate) and water. Concrete is the only material used in construction in the whole world. Water is the important component to get cement hydration process. The hydration process which gives strength to the concrete. It is well known that 'curing' is the main factor to get the strength at early ages to the concrete.

### A. Internal Curing

Internal curing is done by using pre-wetted lightweight aggregates. These light weight aggregates which used as a replacement in fine aggregate. The lightweight aggregates are soaked for 24 hours before the mix is done. When the lightweight aggregates are soaked they absorbs water in their voids, so they act as reservoir in the concrete. These reservoirs which are in the concrete are get released in the time of hydration of cement. Internal curing is defined as "supplying water through the fresh concrete mixture by the reservoirs, via pre-wetted lightweight aggregates, which releases water for the hydration or to replace moisture lost through evaporation". For external curing it is done only on the top surfaces of the cross-section of the concrete and depth of penetration is influenced based on the quality of the mix.

The advantages of ICC reduce early age cracks, shrinkage cracks, lightweight and limited water is used.

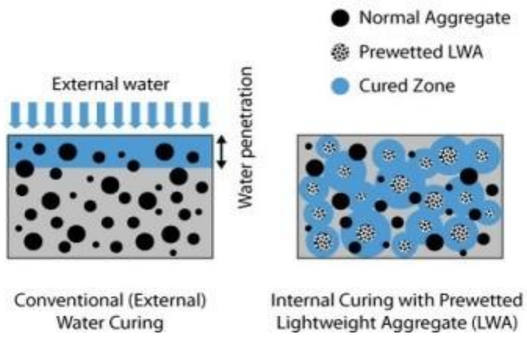


**Fig 1: Figure shows the conventional curing vs internal curing**

### B. Pre-wetted Lightweight Aggregates

In Internal Curing concrete we use pre-wetted lightweight aggregates, initially the lightweight aggregates hold water and acts as a reservoir inside the concrete. The lightweight aggregates like expanded shale, expanded clay, vermiculite, slate and pumice the materials are having a capacity to absorb water inside their pours. They initial pre-wetted for 24 hours before the mix is done. These pre-wetted lightweight aggregates are used in mix as a replacement as fine aggregates in concrete. There will be no change in w/c ratio or the amount of water used in mix. The pre-wetted lightweight aggregates did not influence on the water content used in mix. In this we used vermiculite and expanded clay as lightweight aggregates are soaked in water for 24 hours before the mix.

## II. MATERIALS

### A. Cement

The cement used was locally available brand Ultra-tech (Ordinary Portland Cement) of 53 grade conforming to IS: 12269-1987. The test results conducted for cement are tabulated in below table

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**Table 1:**Properties of Cement

| S.no | Properties | Test Results |
|---|---|---|
| 1 | Normal consistency | 32% |
| 2 | a) Initial setting time<br>b) Final setting time | 45min<br>420min |
| 3 | Fineness of cement | 3.6% |
| 4 | Specific gravity | 3.12 |

### B. Fine aggregates

The locally available sand had been used as fine aggregate conforming to the requirements of IS: 383-1970. The test results conducted for fine aggregate are tabulated in below table

| S.no | Properties | Test results |
|---|---|---|
| 1 | Specific gravity | 2.6 |
| 2 | Fineness modulus | 2.81 |

**Table 2:**Properties of Fine aggregate

### C. Coarse aggregates

The locally available fraction from 20mm to 4.75mm are used as coarse aggregate, conforming to IS: 383. The test results conducted for coarse aggregates are tabulated in below table

| S.no | Properties | Test results |
|---|---|---|
| 1 | Specific gravity | 2.78 |
| 2 | Fineness modulus | 7.29 |

**Table 3:**Properties of Coarse aggregate

### D. Vermiculite

Vermiculite is a mineral, when it applied to heat it get expanded than its original size. The process of heating and expanding is called exfoliation. Vermiculite is passed from furnace which is having a temperature of 540 – 810$^{o}$C, it get expands then it is called exfoliated vermiculite. The test results conducted for vermiculite are tabulated in below table

| S.no | Properties | Results |
|---|---|---|
| 1 | Specific gravity | 2.47 |
| 2 | Water absorption | 10.36% |
| 3 | Density | 225 kg/mm$^3$ |

**Table 4:**Properties of Vermiculite

### E. Expanded Clay

Expanded clay or lightweight expanded clay aggregates (LECA) is a lightweight aggregates are manufactured by heating clay at 1200$^{o}$ c in rotary kiln. Theclay by heating under yielding gases itforms thousands of small bubbles forming inside the clay producing honeycomb structure. Due to circular moment in the rotary kiln the LECA are rounded in shape and is available in different sizes. The test results conducted for expanded clay are tabulated in below table

| S.no | Properties | Results |
|---|---|---|
| 1 | Specific gravity | 1.62 |
| 2 | Water absorption | 24% |
| 3 | Density | 425 kg/mm$^3$ |

**Table 5:**Properties of Expanded clay

## III. EXPERIMENTAL WORK

### A. Concrete mixing

Lightweight aggregates are pre-wetted for 24 hours of period to absorb water in the voids of vermiculite and expanded clay before the mix done. The saturation is very important to these light weight aggregates when the hydration process is started. The pre-wetted aggregates which are once saturated, act as areservoir which releases water when hydration process of cement paste occurs.

A different mixes are casted using both the vermiculite and expanded clay as a light weight aggregates. Vermiculite and Expanded clay are partially replaced with fine aggregate at percentages of 2.5%, 5%, 10% and 12.5% for vermiculite and 5%, 10%, 15%, 20% and 25% for expanded clay. The mix design is taken as $M_{30}$. The below table showsmix proportions of $M_{30}$ grade concrete

| **Materials** | **Quantity** |
|---|---|
| Cement | 437.75 kg/m$^3$ |
| Water | 175.1 liters |
| Fine aggregate | 676.78 kg/m$^3$ |
| Coarse aggregate | 1218.89 kg/m$^3$ |
| w/c | 0.4 |

**Table 6:**Mix proportion

The cubes and cylinders were casted according to the quantities as shown in above tables. Cubes with sizes of 150mmx150mmx150mm and cylinders with sizes of 150mmx300mm. Cubes for compressive strength and cylinders for split tensile strength. The cubes and cylinders are removed from the specimen after 24 hours of casting. The cubes were kept at air curing at ambient temperature.

## IV. EXPERIMENTAL RESULTS

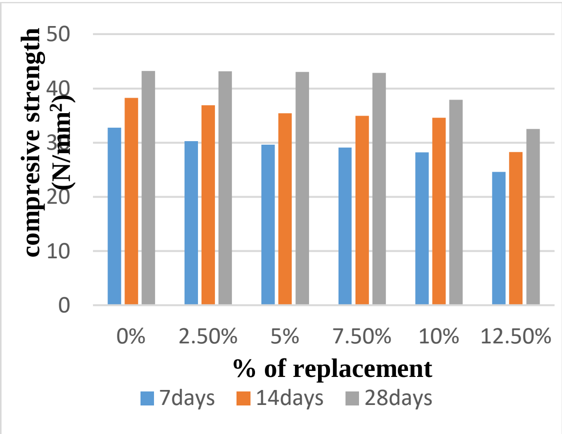
Compressive strength and split tensile strength of cubes were tested at 7 days, 14 days and 28days, reported the average value of 3 cubes.

### A. Compressive Strength

#### i) For Vermiculite

| % of vermiculite | Compressive Strength (N/mm$^2$) | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| 0% | 32.75 | 38.24 | 43.25 |
| 2.5% | 30.28 | 36.91 | 43.16 |
| 5% | 29.62 | 35.42 | 43.02 |
| 7.5% | 29.09 | 34.96 | 42.86 |
| 10% | 28.22 | 34.60 | 37.91 |
| 12.5% | 24.58 | 28.25 | 32.54 |

**Table7:**Compressive strength of vermiculite concrete

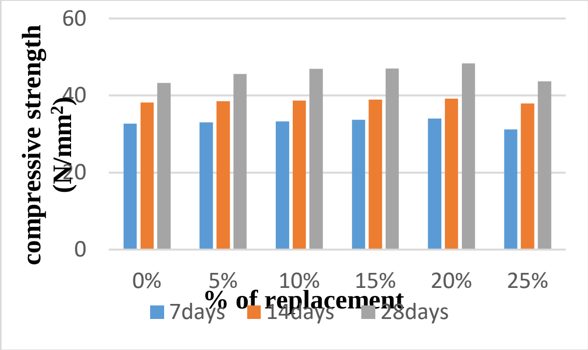



**Graph 1:** Graph shows the results of compressive strength of vermiculite concrete

#### ii) For Expanded Clay

| % of Expanded Clay | Compressive Strength (N/mm$^2$) | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| 0% | 32.75 | 38.24 | 43.25 |
| 5% | 33.06 | 38.52 | 45.64 |
| 10% | 33.27 | 38.71 | 46.98 |
| 15% | 33.69 | 38.98 | 47.03 |
| 20% | 34.01 | 39.21 | 48.34 |
| 25% | 31.19 | 37.95 | 43.68 |

**Table 8:** Compressive strength of expanded clay



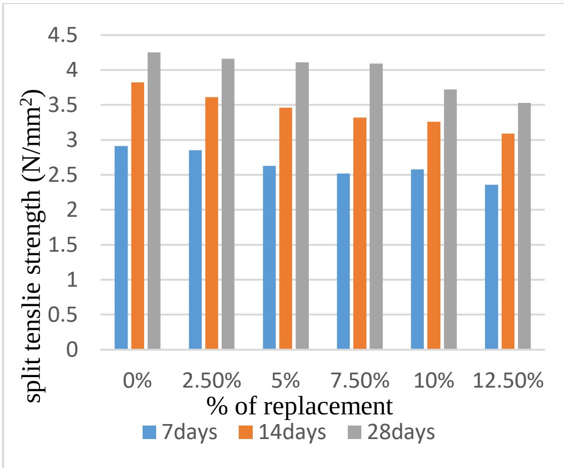

**Graph 2:** Graph shows the compressive strength of expanded clay concrete

### B. Split Tensile Strength

#### i) For Vermiculite

| % of vermiculite | Split Tensile Strength (N/mm$^2$) | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |
| 0% | 2.91 | 3.82 | 4.25 |
| 2.5% | 2.85 | 3.61 | 4.16 |
| 5% | 2.63 | 3.46 | 4.11 |
| 7.5% | 2.52 | 3.32 | 4.09 |
| 10% | 2.58 | 3.26 | 3.72 |
| 12.5% | 2.36 | 3.09 | 3.53 |

**Table 9:** Split tensile strength of vermiculite concrete



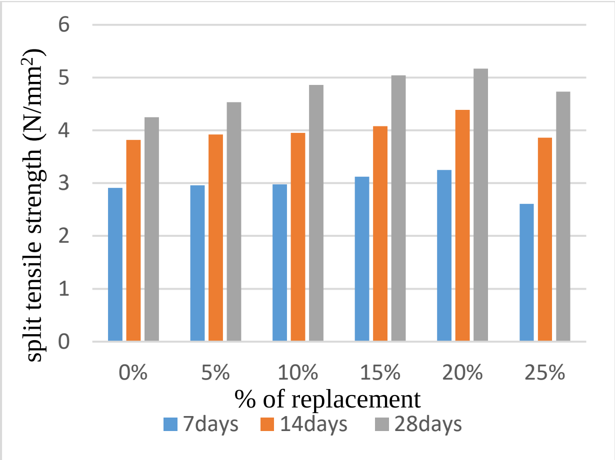

**Graph 3:** Graph shows the split tensile strength of vermiculite concrete

#### ii) For Expanded Clay

| % of Expanded Clay | Split Tensile Strength (N/mm$^2$) | | |
|---|---|---|---|
| | 7 days | 14 days | 28 days |

| | | | |
|---|---|---|---|
| 0% | 2.91 | 3.82 | 4.25 |
| 5% | 2.96 | 3.92 | 4.53 |
| 10% | 2.98 | 3.95 | 4.86 |
| 15% | 3.12 | 4.08 | 5.04 |
| 20% | 3.25 | 4.39 | 5.17 |
| 25% | 2.61 | 3.86 | 4.73 |

**Table 10:** Split tensile strength of expanded clay



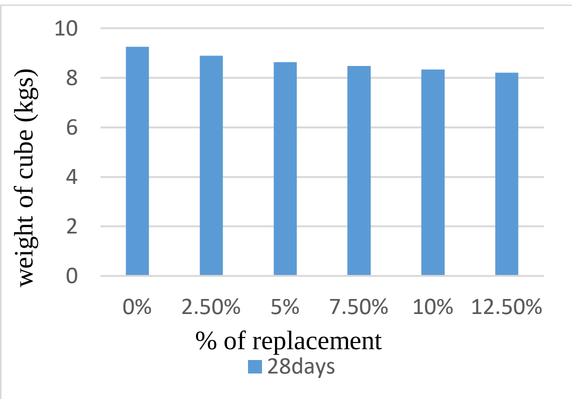

**Graph 4:** Graph shows the split tensile strength of expanded clay concrete

**C. Cube Weight**

**i) For Vermiculite**

| % of replacement | weight of cube (kgs) |
|---|---|
| 0% | 9.25 |
| 2.5% | 8.89 |
| 5% | 8.63 |
| 7.5% | 8.48 |
| 10% | 8.34 |
| 12.5% | 8.21 |

**Table 11:** Weight of the vermiculite concrete

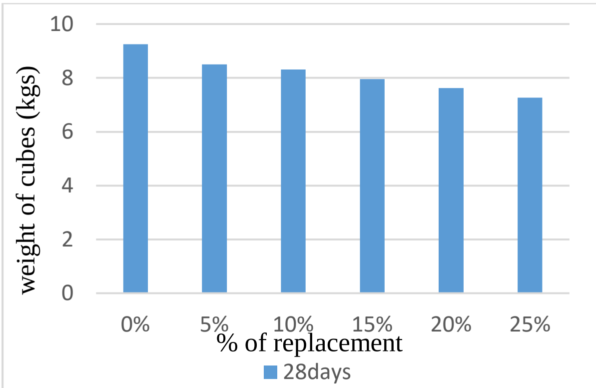



**Graph 5:** Graph shows the weight of the vermiculite concrete

**ii) For Expanded Clay**

| % of Expanded Clay | Weight of Cube (kgs) |
|---|---|
| 0% | 9.25 |
| 5% | 8.51 |
| 10% | 8.32 |
| 15% | 7.96 |
| 20% | 7.62 |
| 25% | 7.27 |

**Table 12:** Weight of the expanded clay concrete



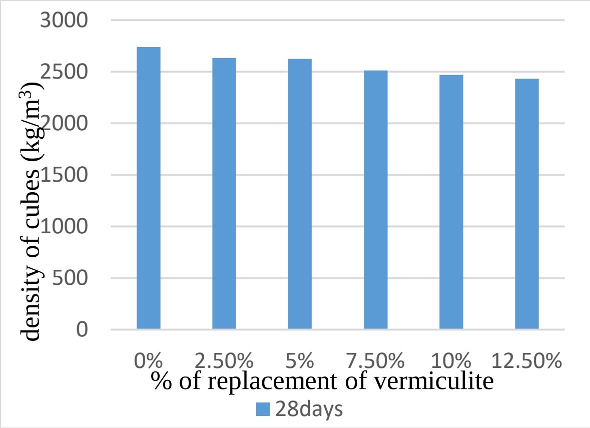

**Graph 6:** Graph shows the weight of the expanded clay concrete

**D. Density of Cubes**

**i) For Vermiculite**

| % of Vermiculite | Density of Cubes (kg/m$^3$) |
|---|---|
| 0% | 2740.74 |
| 2.5% | 2634.07 |
| 5% | 2625.18 |
| 7.5% | 2512.59 |
| 10% | 2471.11 |
| 12.5% | 2432.59 |

**Table 13:** Density of concrete with different % of replacement of vermiculite

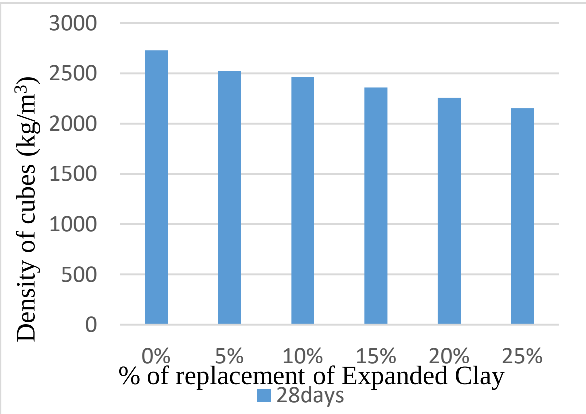



**Graph 7:** Graph shows the density of concrete with different % of replacement of vermiculite

**ii) For Expanded Clay**

| % of Expanded Clay | Density of Cubes (kg/m$^3$) |
|---|---|
| 0% | 2728.88 |
| 5% | 2521.48 |
| 10% | 2465.18 |
| 15% | 2358.51 |
| 20% | 2257.77 |
| 25% | 2154.07 |

**Table 14:** Density of concrete with different % replacement of expanded clay




**Graph 8:** Graph shows the density of concrete with different % replacement of expanded clay

## V. CONCLUSIONS

1) Based on this experiment, it is found that vermiculite and expanded clay can be used as an alternative material to natural river sand and can be used as a constructional material.
2) The compressive strength and tensile strength for vermiculite is less than the conventional concrete, but up to 7.5% of replacement the compressive strength are obtained more than target mean strength.
3) The optimum compressive strength and split tensile strength for expanded clay is at 20%.
4) There is an increase in percentage of compressive strength as compared with nominal mix is increased by using expanded clay by 11.54% (44.34 N/mm$^2$) for 28 days.
5) The percentage increased in split tensile strength as compared with nominal mix is increased by using expanded clay by 10.11% (4.68 N/mm$^2$).
6) For both the vermiculite and expanded clay, when increased in percentage of replacement there is decrease in weight of concrete.

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